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# WOODS HOLE OCEANOGRAPHIC INSTITUTION

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Reference No. 63-9  
  
OCEANOGRAPHIC AND UNDERWATER  
ACOUSTICS RESEARCH  
  
conducted during the period  
1 May 1962 - 31 October 1962

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**WOODS HOLE OCEANOGRAPHIC INSTITUTION**  
**Woods Hole, Massachusetts**

Reference No. 63-9

**OCEANOGRAPHIC AND UNDERWATER  
ACOUSTICS RESEARCH**

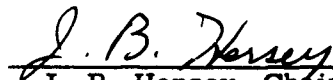
conducted during the period  
1 May 1962 - 31 October 1962

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March 1963

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J. B. Hersey, ~~Chairman~~  
Department of Geophysics

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**ABSTRACT**

During the period of this status report (1 May - 31 October 1962) several long North Atlantic Ocean cruises were made on CHAIN which continued investigations of sound transmission and gravity, made continuous seismic refraction profiles and used radio-acoustical buoys to study the sound reflecting properties of the sea floor. Tests of new instruments and short term investigations were made from BEAR in waters near Woods Hole.

## INTRODUCTION

The Geophysics Department has concentrated on developing improvements to various familiar sea-going instruments and on using them at sea. Those instruments for detecting and measuring transient sounds received by hydrophones have received the most attention. The Continuous Seismic Profiler has been altered by improving the Sparker and Boomer sources, by converting from single hydrophones to a line array for receiving, and by completing electronic programmers for the Precision Graphic Recorder. These improvements have increased the speed of the ship at which good seismic reflection observations can be made, from about 2.5 to 7 knots, and increased also the reliability and efficiency of these studies.

The radio-acoustic buoys used for studying bottom reflectivity have been greatly improved as a result of drastic redesign. They have been tested repeatedly at sea to ranges of 80 miles. Except for limited battery life (8 hours) they appear ready to be used extensively for quantitative study of bottom reflections from normal to grazing incidence and over the frequency range from 10 to 5000 cps. They are to be used as extensively as our schedule will allow during the cruise of CHAIN starting just as this reporting period ends.

Data from the thermistor chain from various cruises of the CHAIN have been used for the studies of internal waves, deep currents, and thermal fronts described below. This data has been drawn also on by workers under other contracts for specific studies of the effect of temperature structure on sound transmission (see WHOI Ref. 61-29) and for an ocean-wide study of the frequency distribution of internal waves. The results from the thermistor chain are deficient because the thermistors are too widely spaced, and because individual thermistor circuits fail too frequently. The interesting improvements to this apparatus which were reported in the last semi-annual status report (WHOI Ref. 62-15), have not become available because of faulty production of underwater components. Nevertheless, tests at sea have demonstrated that the new designs operate properly and we hope to have them available soon.

Use of the NBS sound velocimeter has been made considerably more reliable and the results more accurate by improvements to the inverted echo sounder used for measuring depth and by introducing a complete, sea-going calibration facility. A most interesting study of the regional variation of sound velocity was made under Project ARTEMIS in the area between Bermuda, the Bahamas, and Puerto Rico. This work was done in conjunction with Dr. Reitzel's heat flow study reported below.



We prepared during this period for a major improvement in means for locating instruments suspended on long cables below ships. This is to be accomplished by acoustical triangulation on a pinger attached to the instrument in question. Pulses from the pinger are received at the ship by a crossed array of receivers held fixed with respect to the ship by being hull-mounted or by being mounted on long athwartships booms (see frontispiece). Precision timers for the pingers, now already in a high state of development, provide a reliable time base for measurements of total travel time to any receiver while travel time differences may be read either from oscilloscope photographs or from a PGR record. This capability is badly needed for navigating instruments used to measure complex topography from positions close to the bottom in deep water, and for controlling dredging, coring, and bottom photography.

We are optimistic at this writing that the instrument systems for measuring transient sounds and those for locating deeply suspended instruments will permit us at last to compare acoustical measurements with direct observation of the ocean floor in a truly definitive way. Similarly these same improvements promise to extend our ability to study other hydroacoustical effects concerned mainly with the properties of the ocean itself.

## PAPERS

The following papers prepared under Nonr-1367(00) were published during this period:

WHOI Contribution No. 1181. Sound Scattering Layers and their Relation to Thermal Structure in the Strait of Gibraltar by R. Frassetto, R. H. Backus, and E. E. Hays. Deep-Sea Research, Vol. 9, Jan./Feb. 1962, pp. 69-72 (also under NSF G 9579).

WHOI Contribution No. 1222. Inverted Echo Sounder by W. Dow and S. Stillman. Marine Sciences Instrumentation, Vol. 1 (1962) pp. 263-272.

WHOI Contribution No. 1223. Use of Precision Graphic Recorder (PGR) in Oceanography by S. T. Knott. Marine Sciences Instrumentation, Vol. 1 (1962) pp. 251-262 (Also under Nobsr 72521).

WHOI Contribution No. 1233. The Atlantic Equatorial Undercurrent by W. G. Metcalf, A. D. Voorhis, and M. C. Stalcup. Journal of Geophysical Research. Vol. 67, No. 6, June 1962, pp. 2499-2508. (Also under Nonr 2196).

WHOI Contribution No. 1270. Predicting Sonic Pulse Shapes of Underwater Spark Discharges by D. D. Caulfield. Deep-Sea Research, Vol. 9, July/Oct. 1962, pp. 339-348.

WHOI Contribution No. 1282. A Self-Contained Portable Tape Recording System for Use by Scuba Divers by L. R. Breslau, J. M. Zeigler, and D. M. Owen. Bulletin de l'Institut Océanographique, Vol. 59, No. 1235, 4 pages, 2 figures. (Also under Nonr 2196, and Nonr 1841(74)).

WHOI Contribution No. 1287. Geophysical Investigation of the Puerto Rico Trench and Outer Ridge by E. T. Bunce, and D. A. Fahlquist. Journal of Geophysical Research, Vol. 67, No. 10, Sept. 1962, pp. 3955-3971. (Primary support from NSF Grant G 7438; minor support by Nonr-1367 (00) and Nobsr-72521).

WHOI Contribution No. 1294. The Ocean Bottom by R. M. Pratt. Science, 26 Oct. 1962, Vol. 138, No. 3539, pp. 490-495. Supported by Nonr-1367(00).

The following paper was published during this period under Contract Nobsr 72521 but believed to be of interest to ONR.

WHOI Contribution No. 1269. A Precisely Timed Submersible Pinger for Tracking Instruments in the Sea by L. R. Breslau, J. B. Hersey, H. E. Edgerton and F. S. Birch. Deep-Sea Research, Vol. 9, Mar. /April, No. 2, 1962, pp. 137-144. (Also under Nonr 1841(74) between ONR and M. I. T.).

The following paper was submitted during this period under Contract Nonr 1367.

WHOI Contribution No. 1319. Great Meteor Seamount by R. M. Pratt. Submitted to Deep-Sea Research.

## REPORTS

The following reports have been completed during this period under Contract Nonr-1367(00) or in conjunction with other contracts as noted.

WHOI Reference No. 62-11. Track Charts, Bathymetry and Location of Observations, CHAIN Cruise #21. Atlantic Ocean, Mediterranean Sea, 16 Aug. - 18 Dec. 1961. R. M. Pratt and F. Workum, Jr.

WHOI Reference No. 62-12. Predicting Sonic Pulse Shapes of Underwater Spark Discharges. D. D. Caulfield. (Also published in Deep-Sea Research; see above.).

WHOI Reference No. 62-18. Track Charts, Bathymetry and Location of Observations of YAMACRAW Cruise #10. Atlantic Ocean, Mediterranean Sea. 21 June - 9 Sept. 1958. D. A. Fahlgvist.

WHOI Reference No. 62-28. Track Charts, Bathymetry and Location of Observations, ATLANTIS Cruise #242. Atlantic Ocean, Mediterranean Sea, Red Sea, Indian Ocean. 3 April - 31 August 1958. D. A. Fahlgvist and C. A. Neuman. Prepared also under Contract Nonr-2196 and NObsr-72521.

## TECHNICAL MEMORANDA

Tech. Memo No. 2-62. Cruise Plan for BEAR Cruise #280. 9 July - 31 July 1962. Elizabeth T. Bunce.

Tech. Memo No. 4-62. Cruise Plan for CHAIN Cruise #34. Oct. - Dec. 1962. C. O. Bowin and Elizabeth T. Bunce.

Tech. Memo No. 5-62. A Precise Timing Control for the Edgerton Pinger. L. R. Breslau. Prepared also under Contract Nonr-1841(74) between ONR and M. I. T.

## OCEANOGRAPHY

### Thermistor Chain Observations (Dr. A. D. Voorhis).

#### A. Survey of Area Southeast of Grand Banks.

From July 5 to July 21 the CHAIN was at sea on a research cruise to the area southeast of the Grand Banks. This cruise was jointly financed by ONR Contract 2196 and ONR Contract 1367. Included in the scientific party were nine summer students. The purpose of the cruise was to determine, if possible, whether there is a two-gyre circulation in the North Atlantic divided by a cold cyclonic ridge of water which is bounded on the south by the Gulf Stream and which extends several hundred miles southeastward from the Grand Banks. The possibility of such a circulation was conjectured and evidence of the ridge has been given by L. Worthington in a recent publication (1962). The surface thermal structure and surface currents were surveyed over a large area using the bathythermograph and GEK (Geomagnetic Electrokinetograph). A series of 17 hydrographic stations were made 30 miles apart in which lowerings were made with the in situ salinometer as well as samples taken with the conventional Nansen bottles. It was found that the Gulf Stream was deflected to the south when it encountered the Newfoundland Rise and that there was a cold ridge of water along its northern boundary which extended to a depth of 1000 meters.

#### B. Investigation of Thermal Fronts in the Deep Ocean Mixed Layer.

We have noticed in the past (WHOI Ref. 62-14, p. 7, sec. D), from the records of the towed thermistor chain, the occurrence of thermal fronts in the deep ocean mixed layer. By thermal fronts we mean abrupt changes in the mixed layer temperature of 1°C or more in a horizontal distance of less than 20 km. Of particular interest has been the area between Bermuda and the Bahama Banks. In every case where the thermistor chain has been towed through this area we have observed at least one frontal boundary separating cold water to the north from warm water to the south. These records extend from 1958 to 1962 and occur for the months March, April, October, November, December. When the position of the front observations are plotted on a chart it appears that they are not strictly a fixed feature. Although they are probably always present they appear to migrate. A front has been studied for many hours at two times separated by 44 days (28 October to 11 December 1962). The locations and results suggest that the front persisted throughout the period.

During the recent cruise of CHAIN to the Puerto Rico Trench (October to December 1962) two thermal fronts were observed on the passage south and also on the return passage north. The frontal crossings occurred at approximately 27°N, 70°W and 31°N, 70°W. In both cases the ships conducted a short survey with the thermistor chain to determine the orientation of the frontal boundary and found it to run from northwest to southeast in both cases. In addition, surface current was measured with a towed GEK and it appeared to be unusually strong at the front indicating that the warm water to the south of the boundary was moving to the east with a speed of nearly a knot. We intend to study the properties of these fronts further with the aim of finding why they are there and whether they are truly a near-surface phenomenon or not.

#### Thermistor Chain Instrumentation (Mr. Erlanger).

A four-wire thermistor cable with 24 thermistors and their associated switching modules was tested on CHAIN Cruise 28. Due to sea water leakage in the cable and instrument packages these tests were unsuccessful.

Since previous tests have shown the switching circuits to be reliable, the cable sections and instrument packages for the four-wire switching system are being redesigned for improved reliability. It is expected that a four-wire switching system will be used in the thermistor chain when it is placed in service again this coming spring.

On CHAIN Cruise 34 the thermistor chain was used with a twisted wire pair harness, as in the past. Records were made throughout the cruise.

#### Bathymetry (Mr. Dunkle).

As of 31 October 1962 compilations of track charts, bathymetry, and location of observations for three more cruises had been completed. All were supported by this contract and were issued as WHOI References (see above). Each report contains track charts for the entire cruise except for the track during special surveys. All types of observations made during the cruise are noted by suitable symbols along the ship's track. The locations of special surveys are noted and shown in detail on separate charts. Soundings were read at equal time intervals, usually every five minutes, and at changes in slope. These are written along the ship's track as often as space permits.

Sound Velocity Measurements (Mr. Caulfield, Dr. Hays, Dr. Reitzel, Mr. Birch, and Mr. Stillman).

The data acquisition rate of the velocimeter was increased by a factor of 5 by the use of more accurate counters. This very increase in rate also reduces the depth range sampled for each reading from 6 feet to 1/2 inch with no sacrifice in accuracy.

A portable calibration unit has been designed and constructed for use at sea. It was successfully tested on ATLANTIS Cruise 282 in July and August 1962 and 31 successful velocimeter lowerings were made. The area studied at this time was a quadrant southwest of Bermuda.

Work has continued on the application of high-speed digital computers in analyzing the data. In conjunction with our sound transmission program, studies are being made to determine the required long and short term time accuracies of the velocities needed for determination of sound paths.

## SUBMARINE GEOLOGY AND GEOPHYSICS

Seismic Refraction Studies in the Western Mediterranean (Mr. Fahlquist).

Analysis of the western Mediterranean Sea refraction data (ATLANTIS Cruise 242 and CHAIN Cruise 7) has been completed. A preliminary draft of a paper discussing the results has been completed. The manuscript is undergoing revision and modification.

A paper entitled, "Seismic Refraction Measurements in the western Mediterranean Sea" was given before the Comité de Morphologie, Géologie and Géophysique Marine at the Monaco meeting of the Commission Internationale Pour L'Exploration Scientifique de la Mer Méditerranée in October, 1962.

Tyrrhenian Sea Cores (Mr. Workum).

Work started earlier on the cores taken in the Tyrrhenian Sea during CHAIN Cruise 21 has been continued and enlarged upon; this work includes petrographic identification of minerals, attempts to trace layers between core sites and to correlate sub-bottom echoes seen on the echo-sounding records with changes in the acoustic properties of the cores.

### Heat Flow (Dr. Reitzel).

A survey of heat flow through the sea floor was made this summer in a region of the North Atlantic roughly bounded by Bermuda, Eleuthera, and Puerto Rico. The results show a remarkable uniformity of heat flow in this region -- 16 stations uniformly spaced over the area agree within their experimental errors of about 10%. The mean heat flow is  $1.13 \mu\text{cal/cm}^2\text{sec}$ ; the standard deviation is only .07, far smaller than is usual in sets of heat-flow measurements at sea. (Another station on the Outer Ridge north of the Puerto Rico Trench, shows a heat flow of  $1.75 \mu\text{cal/cm}^2\text{sec}$ , which is significantly higher than any other measurements made nearby.) The uniformity of these measured values vouches for the worth of our apparatus and technique, and is itself a valuable datum for studies of the crust and upper mantle under the western Atlantic.

### Gravity Program (Dr. Bowin).

The gravity program has progressed to the point where we now have operational an automatic, real-time system for the acquisition and reduction of gravity data at sea.

The system incorporates a digital computer which processes data received from five inputs. These five inputs are from a LaCoste-Romberg sea gravity meter (two inputs), a Litton Electromagnetic Speed Log (EM log), a Sperry Mark 14, mod 2 gyrocompass, and a water-depth input from remote switches. The gravity meter, of course, senses the changes in gravity. The EM speed log and the gyrocompass furnish ship's speed and heading from which position and velocity are calculated. This information is needed for the reduction of the gravity values obtained from the gravity meter. Water depths are used in the geological interpretation of the gravity anomalies and in the calculation of sea bouguer anomalies.

Outputs of samples and computed values are put on both punched paper tape and typewriter. The punched paper tape allows recomputation, merging, or sorting of the data without manual preparation. The typewriter output furnishes a record for monitoring of the system, and assists in the plotting and interpretation of the gravity information while at sea. The computer used in this system is an IBM 1710 control system which includes a 1620 digital computer and a 1711 data converter.

Following a year of planning at WHOI, construction of the input conversion units and the writing of the computer coded program was begun by International Business Machine Corporation in early May, 1962. During the last

week of June the components of the 1710 system arrived at Woods Hole and were then installed aboard the CHAIN in the main laboratory. An air-conditioned room was built around the equipment. On June 30 sea gravity meter S-13 arrived from LaCoste-Romberg of Austin, Texas, and was also installed in the main laboratory. On July 6 the CHAIN departed on Cruise 28, and sea trials of the automatic gravity system began. Debugging and improvements in the coded program and in the input conversion equipment were mainly done on this cruise and CHAIN Cruise 29. Thus, during CHAIN Cruise 30 (in the region between Woods Hole and Bermuda) and 31 (in the New England Seamount province) the system was operational and the running of it had become routine.

A gravity survey, along with continuous seismic profiling, of a relatively large region north of Puerto Rico was conducted during CHAIN Cruise 34. The automatic gravity system allowed contouring of free air and sea bouguer gravity anomaly values while the ship was still in the area. Thus, we were able to modify the cruise plan so that gravity data could be collected in critical places.

#### Magnetic Program

A towed proton-precession magnetometer was built during the early summer and first tested in late July - early August on CHAIN Cruise 29. On CHAIN Cruise 34 the magnetometer was further tested and the output of the magnetometer was tied into the gravity computer system. Some measurements were made north and northwest of Puerto Rico before the towing cable broke and the magnetometer fish was lost. Considerable experience was gained from these tests and will be used to improve both fish design and automation of magnetic data. Construction of a replacement magnetometer fish is underway.

#### Puerto Rico Trench Rocks (Mr. Nalwalk and Dr. Bowin).

The rocks dredged from the north wall of the Puerto Rico Trench (CHAIN Cruise 19) are still being analyzed petrographically, and the results are being checked by X-ray diffraction and chemical analysis. Chemical analysis and radioactive dating of the serpentinite samples has not been completed at this time. Microfossil determination appears to indicate a Lower Tertiary age for the sedimentary rocks.



#### Mid-Atlantic Ridge Rocks and Topography (Mr. Nalwalk and Dr. Pratt).

The results of the petrographic and chemical analysis of the Mid-Atlantic Ridge rocks (CHAIN Cruise 21) are in preparation for publication. Vesicles in one sample of basalt were found to contain foraminifera. The foraminifera have been identified as pleistocene in age; hence the rock is pleistocene or older.

A topographic model of the ridge between 28°N and 34°N has been completed based entirely on recent cruises of CHAIN and ATLANTIS (Figure 1).

#### ATLANTIS Cruises 280, 281 - New England Seamount (Dr. Pratt).

ATLANTIS Cruises 280-281, to the New England Seamounts left Woods Hole June 13, 1962, and returned July 2. Twelve camera lowerings and twenty dredge hauls were made in conjunction with a bathymetric survey over the summits of the seamounts. Attempts to gather information about the underlying rocks of the seamounts were hampered by the cover of glacial gravel and boulders in the near-shore seamounts and by manganese encrustations on the offshore seamounts. Excellent photographs of the manganese nodules encrusting parts of the seamounts were obtained. Chemical and biological analysis of some of the dredge samples is now in progress.

### OCEANOGRAPHIC AND ACOUSTIC INSTRUMENTATION

#### Inverted Echo Sounder (Mr. Dow, Mr. Stillman, and Mr. Clifford).

A second inverted echo-sounder of the same general design as the one described in Marine Science Instrumentation (Vol. 1, pp. 263-272, 1962) is nearing completion. This instrument is designed to provide a continuous and very precise depth determination of instruments being lowered with it into the sea and also to function as a survey instrument for detailed examination of the ocean bottom.

Changes have been made to simplify the circuitry of the deep receiver and to increase its sensitivity. These improvements have also been incorporated into the original unit which, incidentally, has already seen extensive service in connection with the sound velocity program. A new receiver designed to detect, amplify, and separate the telemetered signals coming from the deep instruments has been designed and constructed for use in the ship's laboratory. If successful, this compact unit will replace the elaborate and expensive V. L. F. Receiver

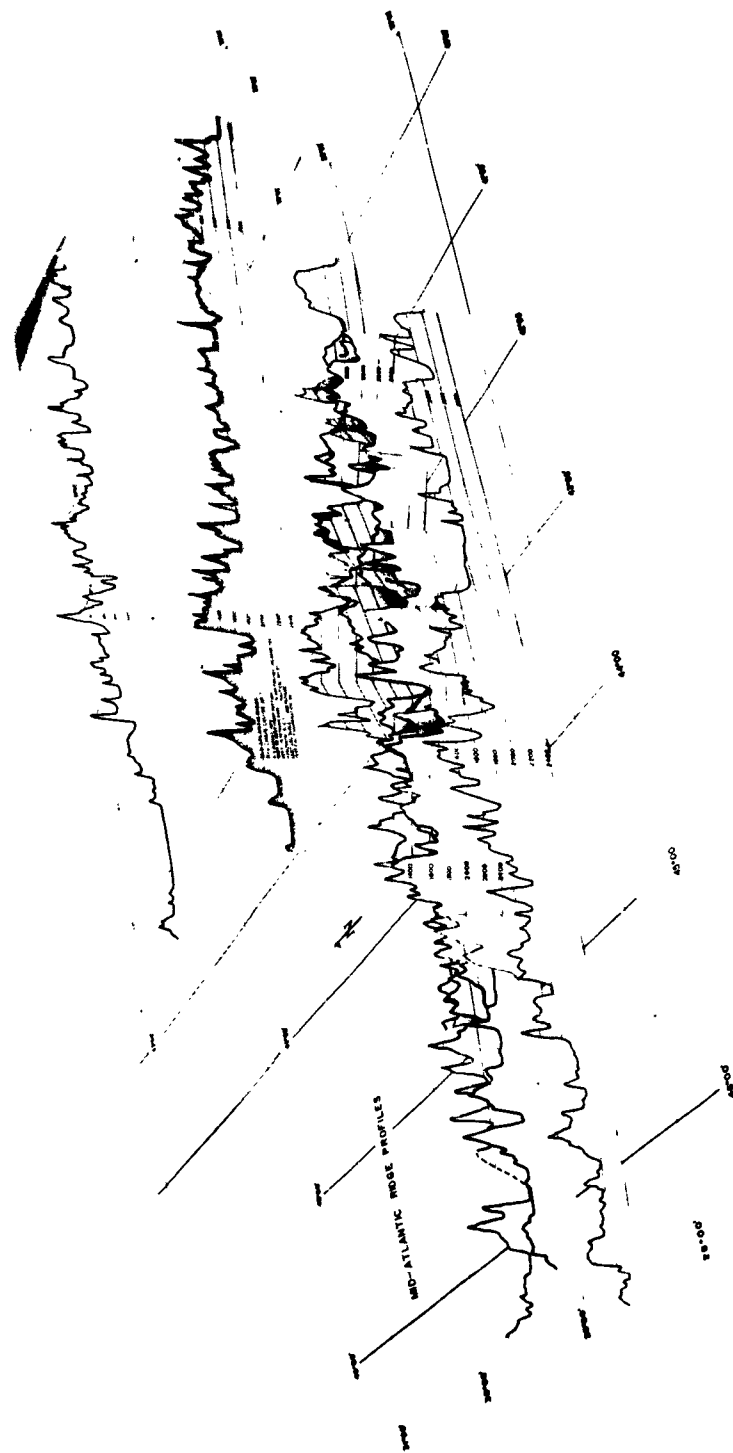


FIGURE NO. 1. PROFILES ACROSS THE MID-ATLANTIC RIDGE FROM  
28°N TO 34°N.

formerly employed for this purpose as well as the array of small electronic chassis heretofore required to process the signal for the readout equipment. It is now possible to operate the power switches on the transmitter and receiver without disturbing the watertight integrity of their pressure cases. This is done by rotating a small magnet mounted in a guide assembly affixed to the outside of the case. The change in magnetic flux through the case wall actuates a reed switch in series with the battery leads.

New miniature connectors particularly designed for high voltage operation in the deep ocean have been developed to our specifications by Mecca Cable and Service, Inc. , Houston, Texas, and are being installed on the echo sounder transducers to replace the generally unsatisfactory terminals with which these units come equipped. The connectors will make testing, repair, and replacement of the transducers a far easier task, particularly at sea.

#### Acoustic Telemetering Buoys (Mr. Dow and Mr. Carter).

Three acoustic telemetering buoys designed for oblique seismic reflection and seismic refraction work were constructed during this period, and sea trials were undertaken aboard the BEAR. The initial tests were designed to determine the range and coverage of the R. F. "ground wave" transmission from buoys operating on three and seven megacycles in the daytime. It was found that at a range of approximately 80 miles the received signal on both frequencies remained well above general background noise. Continuous monitoring indicated no "drop outs" at least out to this range.

A second series of tests was conducted to determine the effectiveness of the buoys for acoustic reflection and refraction work. During these experiments the buoys were either anchored or allowed to drift, as determined by water depth and weather conditions, and the ship steamed away towing an Edgerton Boomer as the sound source.

Bottom reflected energy received by the buoys' hydrophones was radioed back to the ship. There a Precision Graphic Recorder was used both for keying the Boomer and for final readout, so that a properly synchronized record was produced. Excellent sub-bottom profiles have been obtained in this manner both in deep and shallow water.

### Ceramic Hydrophones (Mr. Dow and Mr. Clifford).

Four of the special ceramic hydrophones designed and constructed at WHOI for use with the telemetering buoys described in the preceding section were completed and used with the buoys during the summer testing program. The performance of all units during sea trials appeared to be excellent, and although only one hydrophone has been calibrated so far, the curves for this one indicate flat frequency response in the range 10 cycles-3 kc ( $\pm 3$  db) and adequate sensitivity (-92 db ref. 1 volt/microbar) within limits of the audio pass band of the buoy.

### Seismic Hydrophone Array (Dr. Hersey, Mr. Dow, Mr. Hoskins, Mr. Grant, Mr. Stillman, Mr. Dimmock, Dr. Reitzel, and Mr. Cain).

A linear hydrophone array for seismic research was constructed during this period in cooperation with Chesapeake Instruments, Inc. which supplied that portion of the line containing the receiving and transmitting crystals. The array was designed to be towed at the end of a long neutrally buoyant cable during those seismic profile runs which utilize low frequency sound sources such as the Sparker and Boomer. The array provides vertical directionality, thus discriminating against ship noise in favor of bottom and sub-bottom reflections. The entire assembly is streamlined to minimize water noise due to cavitation.

Two types of preamplifier assemblies were designed and built as impedance match between the array and the connecting cable. The first was a dual-channel unit designed for operation with groups of receiving elements connected in shunt, and the second a five-channel version for experiments where individual recordings from each element were required.

A transmitter was also designed and constructed for use with the array. This unit fed short high power pulses at a one-second repetition rate into the five transmitting elements. The surface-reflected returns were picked up by the receiving elements in the array, amplified, and then fed to the readout devices in the ship's laboratory along with the seismic information. This system permitted continuous monitoring of the depth of all parts of the array while it was being towed.

The array was used quite extensively during CHAIN Cruise 34 to Puerto Rico in the latter part of 1962, and excellent sub-bottom profiles were obtained.

Instrumentation to Extend the Capabilities of the PGR (Mr. Knott and Mr. Witzell).

Various devices have been developed to extend the flexibility and effectiveness of the Precision Graphic Recorder (PGR) in sound transmission and deep sea seismic reflection studies. In the course of these investigations, data is examined on the PGR with high and low resolution in different frequency band widths, is compensated for travel time changes, etc. All these actions are not practically performed simultaneously when the data is taken, so the data is recorded on magnetic tape on which at least one channel is devoted to the time base signal controlling the experiment. These tapes are subsequently played back to a PGR for further analysis. Upon playback the PGR must be programmed in commensurate intervals with the program interval used when the data was taken. (The program interval referred to here is the sweep period of the recording helix multiplied by the number of sweeps between successive recordings.) When data is taken on schedules precisely timed by the PGR's, it is then possible to correlate many successive samples of data essentially automatically. Hence, in two-ship, ship-to-shore, and master-and-slave operations, the time bases of the PGR's are synchronized.

It is frequently desirable to play back magnetic tape recordings of data timed by a PGR at sea to a PGR in the laboratory at a tape transport speed higher than the original. This is done either to speed analysis or to make use of filters designed for higher frequencies. However, the effective program interval of the data played back must be commensurate with a program interval on the PGR. In the older, mechanically controlled programs matching programs are so restricted in number that the versatility of the PGR is greatly reduced. (The mechanical PGR programmer limits the number of sweeps between successive recordings to integral fractions of twelve.) This limitation has been removed by the electronic PGR programmer (see WHOI Ref. No. 62-15, p. 11). This programmer will allow any number of sweeps between recordings from 1 to 99.

In order to reduce analysis time, magnetic tapes are often played back to the PGR's at a speed two or four times higher than that used when data was taken. This speed-up of the tape necessitates programming adjustments which are now solved by the electronic programmer, but the time base frequency recorded (60 c/s) is now multiplied by the speed-up factor and must be divided as playback speed is increased in order to drive the PGR once again. Several frequency division systems have been made and the four-to-one dividers within the tuning fork units of the PGR's have been modified to accomplish this purpose. A series of multipliers is also being made up.

In addition, several frequency shifting devices have been developed to compensate our correlation displays for changes in travel time (TTC or travel time compensation). When travel times are increasing or decreasing, the period between samples of data originated on a precise time schedule is shortened upon reception when travel times are decreasing, and lengthened when travel times are increasing. If the period between samples is shortened by a travel time decreasing with time, a small increase in the writing rate of the recorder can be used to bring the samples of data on successive sweeps into useful alignment. This technique is introduced in the following ways during those experiments based upon the maintenance of a precise originating schedule for data sampling.

1. The time base of the PGR that is recording received data in the field is altered to compensate for travel time changes; however, the precise PGR time base is recorded on magnetic tape together with the data but on separate channels. (If more tape recording channels are available the TTC time base and scale lines are also recorded.) Two PGR's are also often used as master and slave, the slave display commonly being travel-time-compensated. The TTC components used to date in this application (other than manual differential inputs) have been driven by tuning forks which are pulled off frequency by either permanent or electro-magnets.

2. Upon playback from tape, other methods are required, since even those tape transports running off power supplies with precisely controlled frequency do not reproduce timing to the order of one part in  $10^5$  and more often ship's AC power has driven the capstan. But, the data is tied to the originating time base because it was recorded simultaneously. The precision 60 c/s time base signal recorded on the tape can be considered upon playback to be only nominal 60 cycle. Our present method for developing TTC signals from the nominal 60-cycle time base signal is to drive a synchronous motor couples to a ball and disc variable drive (integrator) coupled in turn to a phonic wheel frequency generator. In this simple way the modified time base generated by the phonic wheel can be made to remain a certain percentage of the time base signal originally recorded even though the recorded signal may drift due to tape slippage or drive speed.

Another electro-mechanical device, the Sweep Synchronized Positionable Trigger, has been designed to give the PGR operator a means, as the name suggests, to trigger other equipment at any time determined by PGR sweep speed and increment of sweep interval chosen by the operator. The heart of the device is a differentially controlled contact made by a magnetic reed switch. The differential action is required to enable the trigger position to be adjusted

during sweep periods. A visual reference of the trigger position on the recording can be made with the use of circuitry existing in the PGR. The trigger contact closure time can be recorded as a short pulse or actual contact closure time.

While adapting the reed switch and magnet to a gyro repeater for recording the ship's course on the PGR, it became obvious that positioning of the closure of the switch could be done manually instead of by using the gyro repeater, thus making a very effective variable positionable trigger for external units such as oscilloscopes, relays, and cameras. This positionable trigger has also been used as part of a semiautomatic ocean depth input to a shipboard IBM computer. The frame of the trigger unit is designed to accept conveniently additional servomount devices such as potentiometers to sense the position of the trigger and as sweep generator components for synchronizing the sweep of an oscilloscope to the sweep of the PGR.

Spark Sound Source - 25,000 watt/sec. (Mr. Caulfield).

The Big Sparker was used extensively on CHAIN Cruises 29, 30, 31, and 34 for seismic reflection profiling and sound transmission work. The major areas of study were the continental shelf and the shelf canyons off southern New England, the New England seamounts, the Bermuda Rise, Nares Basin, and the outer ridge north of the Puerto Rico Trench. During this period some capacitors failed and replacement was necessary. With the capacitors now in use a million firings are about the life limit.

A study is underway to find a low-priced substitute for these capacitors that has a high life expectancy. One major problem affecting lifetime of the storage capacitors is the large temperature range that the device is required to operate in. Air-conditioning should resolve this problem.

On CHAIN Cruise 34 new electrodes of various metallic composition were tested. The electrode problem is still not solved. During the winter we will attempt to develop easier-to-change and more reliable electrodes.

Precision Time Source for Remote Control (Mr. Hess and Mr. Breslau).

During this period two prototype timers for remote control of instruments lowered into the sea have been constructed and tested. At room temperatures the accuracy and long term stability have been well within the design

objectives, i. e.  $\pm 1$  part in  $10^7$ . The package, as shown in Fig. 2, was designed to be inserted into a standard pinger/camera pressure case. Printed circuits and miniature components allowed this device to be constructed so that it takes no more space than the electro-mechanical timer which it replaced.

On CHAIN Cruise 34 the device was tested at sea. Two lowerings were made to 300 and 3200 fms, respectively. The timer behaved as expected during the shallow lowering but failed at a depth of 3150 fms during the deep lowering. The failure was partially a result of temperature dependent circuitry and partially a result of less than perfect tuning of the synchronized relaxation oscillators in the frequency divider section. During the periods of proper operation it was shown to be possible to get good range and bearing information based on the accurately known rate of the timer.

Work is now progressing on temperature compensation to reduce the temperature dependence of the circuitry and therefore make the final tuning a less delicate operation in order that the instrument will function in any environment likely to be encountered. The limited sea trials undertaken thus far indicate that the device will perform its intended function, that of allowing close tracking of a submerged object.

#### Extensible Platforms (Mr. Knott, Mr. Witzell and Mr. Hess).

From the trial and use of one extensible platform or hydrophone boom on CHAIN Cruise 21 it became apparent that several modifications in its design would have to be made prior to use on CHAIN Cruise 34. To this end BEAR was outfitted with the same platform in early summer for further trials and modifications.

During the original trials on the CHAIN and the first trials on the BEAR the following short-comings were observed:

##### Mechanical:

1. The universal joint or pivot for the boom at the ship was wrongly oriented. The vertical pivot was on the boom, the horizontal on the ship separated by some ten inches, which resulted in a toggle action.
2. Walkway railing broke loose too easily.
3. Float-supporting pipe, (similar to a rudder post) became bent under normal operations.



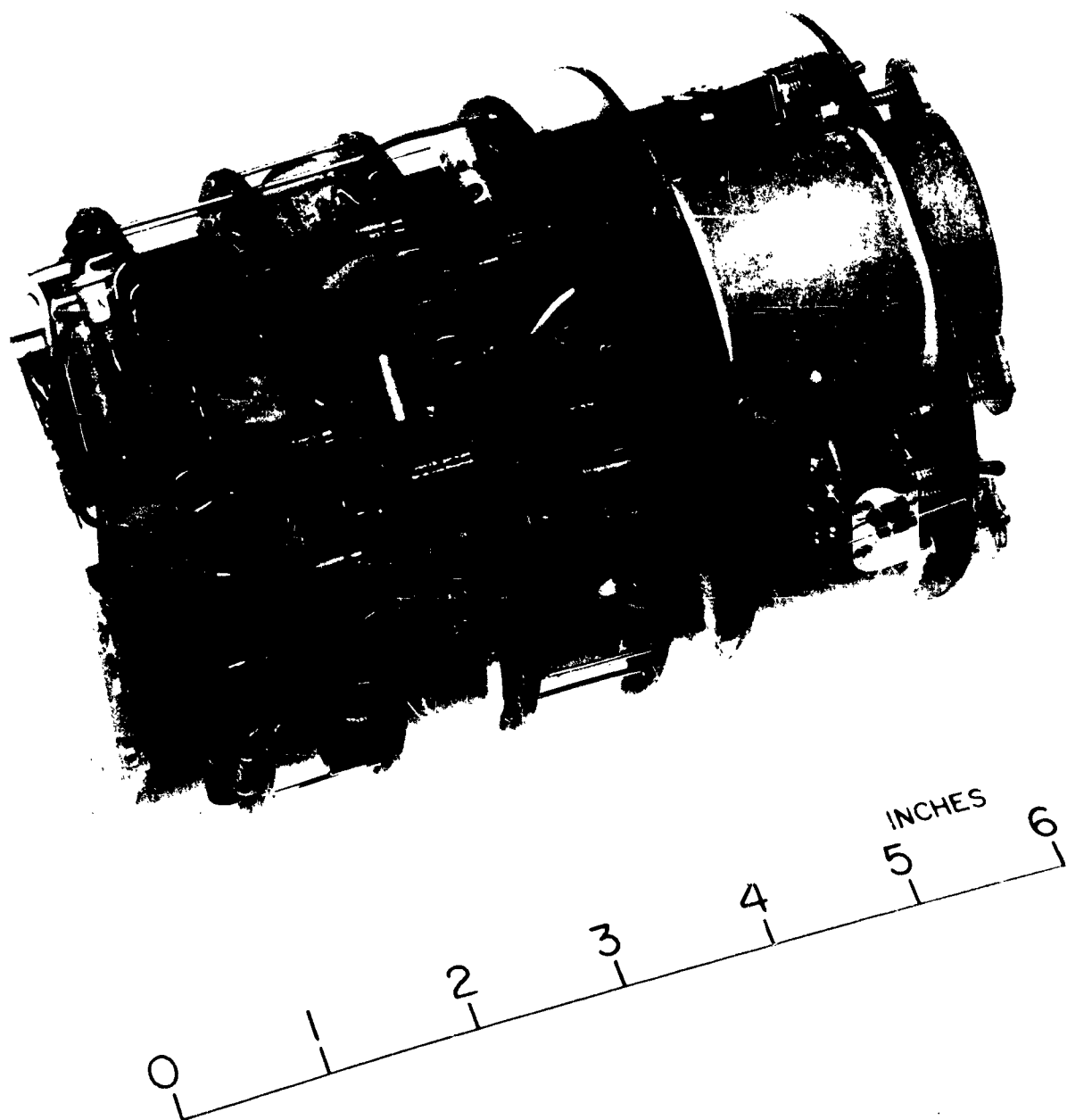


FIGURE NO. 2. PROTOTYPE OF PRECISION TIME SOURCE FOR REMOTE CONTROL OF INSTRUMENTS LOWERED INTO THE SEA.

4. The bearings permitting the float or pontoon to pivot on the pipe were stiff and easily jammed.
5. Better seagoing storage of platform and float was required.
6. Attaching the float to the platform was dangerous and awkward.
7. There was insufficient space for installation of a transducer in the bottom of the float.

Towing Characteristics:

8. The float assumed a 30° angle, either side of the direction of water flow.
9. The float had a tendency to be sucked down dangerously at speeds above six knots.
10. The excessive bow wave of the float created too much disturbance even at speeds less than six knots.
11. Float did not have enough buoyancy for the addition of equipment.

Electrolysis:

12. There was excessive corrosion on submerged portion of the float.

Item by item of above, the following modifications were made:

Mechanical:

1. The shipboard side of the universal joint was changed to the vertical position to prevent the float from flipping when the platforms were being extended and retrieved. This also permitted the platform and float to be lifted from the horizontal position approximately 30°, for storage into a holding crotch toward the stern of the towing vessel.

2. To strengthen the walkway railing, heavier pipe, better welding, different fastening points and bolts were utilized.
3. The float-pivot pipe or rudder post was originally standard aluminum pipe. The forces acting upon the float and boom apparently were greater than originally calculated because it did bend. The rudder post was changed to schedule 80 (or double thick-walled aluminum pipe) and has been sufficient thus far, even with an extension on the bottom of the float creating a greater lever arm.
4. The float pivot bearings have been improved with the addition of grease grooves, grease fittings, and better adjustment.
5. The storage of the platforms with their floats intact and connected to the ship by the universal pivot and the rigging of guys for shipping and unshipping the platforms at sea can be quite a problem. On the BEAR the platform was swung aft and hoisted so that the float cleared the water. Our solution on the CHAIN was similar though still awkward. The ship-mounted universal joint was about three quarters of the ship's length aft where the main deck is first exposed. This was approximately eight feet above the water line. Fifty feet further aft, and fourteen feet above the main deck, a crotch was built at the rail to hold the platform and float when not in use. The crotch height was necessary to permit the use of an "A" frame used for lowering other equipment over the side when the platform was in the stowed position and to clear pontoon from the water. Handling and storage of the platform with this arrangement was very successful. The objections arose when other pieces of gear being handled by the ship's crane had to go over or around the platforms and floats.
6. The clamps attaching the float and platform together are not hinged and bolted. Floats can be fastened to the platforms quickly and safely when platforms are resting in the crotches.
7. Enough space for the installation of a UQN type transducer was obtained by extending the float one foot at the bottom and having a well below the pivot pipe for this purpose.

#### Towing Characteristics:

8. The towing performance of the float was improved by changing the effective length-width ratio by adding a sharper bow and two vertical tail fins on the submerged portion of the float, starting at and extending two feet behind the trailing edge of the float. The space between the fins was made to be as great as the maximum width of the float in order that they be in non-turbulent water and have a greater correcting moment.
9. The first float had a flat bottom, with a large bearing housing protruding which contributed to the suction problems at speeds greater than six knots. A combination of sharpening and streamlining the bottom section, which also enclosed the bearing housing, permitted speeds up to nine knots in relatively calm water without excessive danger of sucking the platform and float underwater. Experimental changes in shape were made with foam and fibre-glas and later fabricated of aluminum and foam.
10. Transforming the shape of a blunt bow on the float to a fairly sharp leading edge accomplished three things. The float now knifes through the water instead of pushing the water ahead, up, and out around the leading edge. The air-water interface problems, although not completely solved, are lessened; the water line, which, at six knots, first sloped more than  $45^\circ$ , was more nearly horizontal after sharpening. The self-generated acoustic noise is much lower.
11. The displacement problems were solved by a one-foot addition at the bottom of the float which provided space for the transducer. Additional buoyancy was gained by added volume in sharpening the bow and in fairing the bottom.

#### Electrolysis:

12. Electrolysis of the submerged portion of the float was reduced by the installation of expendable aluminum blocks fastened in the area of corrosion for cathodic protection.

### Transducer Installation for Acoustic Direction Finding.

Transducers employing the UQN crystal array were installed in the float wells, which have an 18-gauge stainless steel acoustic window. The window is curved and faired to the shape of the float to prevent turbulence. The transducers are shock mounted. Each transducer can be tilted 30° and trained 360° by controls located at the top of the pivot pipe which supports the float.

### Processing of Ocean Bottom Photographs (Miss Broughton and Mrs. Gallagher).

The processing program for ocean bottom photographs has continued. Mounting and cataloging of photographs for the following cruises has been completed.

ATLANTIS 251	1819 pairs	414 singles
CHAIN 5	-----	206 singles
CHAIN 11	1577 pairs	655 singles
CHAIN 17	72 pairs	233 singles
CHAIN 21	3259 pairs	91 singles

Photographs from ATLANTIS Cruise 266 are now being processed. 796 pairs and 712 singles have been mounted and catalogued to date.

### REFERENCES

Worthington, L. V. , 1962. Evidence for a Two Gyre Circulation System in the North Atlantic. Deep-Sea Research, Vol. 9: 51-67.

## APPENDIX

### Use of Vessels

Operation of R/V CHAIN during this period was as follows:

<u>Cruise No.</u>	<u>Departure Return</u>	<u>Work Area</u>	<u>Principal Investigations</u>	<u>Scientist in Charge</u>
28	6 July 1962 24 July 1962	Atlantic Ocean	E/S - Bathymetry, Gravity Studies.	L. V. Worthington C. Bowin
32	11 Sept. 1962 21 Sept. 1962	Gulf of Maine	Sound-scattering, fish studies, bio- luminescence, whale sounds, mid- water trawling.	R. H. Backus
34	18 Oct. 1962 31 Oct. 1962	San Juan - P. R. Trench	Gravity observations, continuous seismic refraction/reflection profiling, photograph- ing and dredging the ocean floor.	J. B. Hersey

Operation of R/V BEAR during this period was as follows:

278	17 June 1962 22 June 1962	New England Seamounts	Continuous seismic profiling with the 5 K Boomer.	T. R. Stetson
279	25 June 1962 30 June 1962	Continental Shelf	Seismic refraction and reflection obser- vations.	L. Bennett
280	10 July 1962 30 July 1962	Onslow Bay Continental Shelf	Seismic refraction observations and bathymetry.	E. Bunce
283	24 Aug. 1962 27 Aug. 1962			J. B. Hersey R. Pearson

Operation of R/V BEAR (continued):

<u>Cruise No.</u>	<u>Departure Return</u>	<u>Work Area</u>	<u>Principal Investigations</u>	<u>Scientist in Charge</u>
284	7 Sept. 1962	Buzzards Bay 41°4.13'N-70° 41.25'W	Seismic refraction observations	S. T. Knott
285	8 Sept. 1962	Martha's Vineyard 50 fm. contour	Instrumentation for PGR, bottom photography, Van Veen samples.	L. Breslau
286/ 289	19 Sept. 1962 23 Sept. 1962	Vineyard Sound	4 seismic refraction profiles with radio buoys.	W. Dow
290	1 Oct. 1962 3 Oct. 1962	Martha's Vineyard, Block Island	Echo measurement profiles, echo soundings, Van Veen lowerings, stereo camera lowerings	L. Breslau
291	4 Oct. 1962 11 Oct. 1962	Narrangansett Bay, L. I. sound & R. I. sound	Continuous seismic data, bore hole data, subbottom data, Van Veen samples, bottom photographs.	A. Nalwalk

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